toresistive-effect device cannot feed an effective sense current to the sensitive region, and suffers from a drop in the reproduction output as the direct current resistance increases.

SUMMARY OF THE INVENTION

[0018] Accordingly, it is an object of the present invention to provide a magnetoresistive-effect device which reduces a direct current resistance by overlapping an electrode layer over an insensitive region of a multilayer film to improve reproduction characteristics, and a method for manufacturing the magnetoresistive-effect device.

[0019] According to a first aspect of the present invention, a magnetoresistive-effect device includes a multilayer film including an antiferromagnetic layer, a pinned magnetic layer, which is deposited on and in contact with the antiferromagnetic layer, and the magnetization direction of which is pinned through an exchange anisotropic magnetic field with the antiferromagnetic layer, and a free magnetic layer, separated from the pinned magnetic layer by a nonmagnetic electrically conductive layer, a pair of hard bias layers, deposited on both sides of the multilayer film, for orienting the magnetization direction of the free magnetic layer perpendicular to the magnetization direction of the pinned magnetic layer, and a pair of electrode layers respectively deposited on the hard bias layers, wherein the electrode layers extend over the multilayer film.

[0020] Preferably, the first magnetoresistive-effect device includes the multilayer film including the antiferromagnetic layer, the pinned magnetic layer, which is deposited on and in contact with the antiferromagnetic layer, and the magnetization direction of which is pinned through an exchange anisotropic magnetic field with the antiferromagnetic layer, and the free magnetic layer, separated from the pinned magnetic layer by the nonmagnetic electrically conductive layer, the pair of hard bias layers, deposited on both sides of the multilayer film, for orienting the magnetization direction of the free magnetic layer perpendicular to the magnetization direction of the pinned magnetic layer, and the pair of electrode layers respectively deposited on the hard bias layers, for feeding a sense current to the pinned magnetic layer, the nonmagnetic electrically conductive layer, and the free magnetic layer, wherein the multilayer film includes a central sensitive region which provides an excellent reproduction gain, exhibiting a substantial magnetoresistive effect and insensitive regions which are formed on both sides of the sensitive region, and provide a poor reproduction gain, exhibiting no substantial magnetoresistive effect, and wherein the electrode layers deposited on both sides of the multilayer film extend over the insensitive regions of the multilayer film.

[0021] Preferably, the multilayer film is fabricated by successively laminating the antiferromagnetic layer, the pinned magnetic layer, the nonmagnetic electrically conductive layer, and the free magnetic layer in that order from below, the antiferromagnetic layer laterally extends from the layers laminated thereon, and a pair of hard bias layer, a pair of intermediate layers, and a pair of electrode layers are respectively laminated on a pair of metallic layers respectively deposited on the antiferromagnetic layers in laterally extending regions thereof.

[0022] According to a second aspect of the present invention, a magnetoresistive-effect device includes a multilayer film including a free magnetic layer, nonmagnetic electrically conductive layer respectively lying over and under the free magnetic layer, pinned magnetic layers respectively lying over the one nonmagnetic electrically conductive layer and under the other nonmagnetic electrically conductive layer, each having a pinned magnetization direction, and antiferromagnetic layers respectively lying over the one pinned magnetic layer and under the other pinned magnetic layer, and a pair of hard bias layers, formed on both sides of the multilayer film, for orienting the magnetization direction of the free magnetic layer perpendicular to the magnetization direction of the pinned magnetic layer, and a pair of electrode layers respectively deposited on the hard bias layers, wherein the electrode layers extend over the multilayer film.

[0023] Preferably, the magnetoresistive-effect device includes the multilayer film including the free magnetic layer, nonmagnetic electrically conductive layers respectively lying over and under the free magnetic layer, pinned magnetic layers respectively lying over the one nonmagnetic electrically conductive layer and under the other nonmagnetic electrically conductive layer, each having a pinned magnetization direction, and antiferromagnetic layers respectively lying over the one pinned magnetic layer and under the other pinned magnetic layer, and the pair of hard bias layers, deposited on both sides of the multilayer film, for orienting the magnetization direction of the free magnetic layer perpendicular to the magnetization direction of the pinned magnetic layer, and the pair of electrode layers deposited on the hard bias layers, for feeding a sense current to the pinned magnetic layer, the nonmagnetic electrically conductive layer, and the free magnetic layer, wherein the multilayer film includes a central sensitive region which provides an excellent reproduction gain, exhibiting a substantial magnetoresistive effect and insensitive regions which are formed on both sides of the sensitive region, and provide a poor reproduction gain, exhibiting no substantial magnetoresistive effect, and wherein the electrode layers deposited on both sides of the multilayer film extend over the insensitive regions of the multilayer film.

[0024] Preferably, the free magnetic layer includes a plurality of soft magnetic thin films having different magnetic moments and nonmagnetic material layers, which are alternately laminated with one soft magnetic thin film separated from another by one nonmagnetic material layer, and the free magnetic layer is in a ferrimagnetic state in which the magnetization directions of two adjacent soft magnetic thin films, separated by the nonmagnetic material layer, are aligned antiparallel to each other. This arrangement offers the same result as the one obtained from the use of a thin free magnetic layer. The magnetization of the free magnetic layer is easily varied, improving the magnetic field detection sensitivity of the magnetoresistive-effect device.

[0025] The magnitude of the magnetic moment of the soft magnetic thin film is the product of the saturation magnetization (Ms) and the film thickness (t) of the soft magnetic thin film.

[0026] When the free magnetic layer is fabricated by alternately laminating a plurality of soft magnetic thin films having different magnetic moments and nonmagnetic material layers, the magnetization directions of two adjacent soft magnetic thin films, separated by the nonmagnetic material